A

GEOLOGICAL REPORT

ON THE

KYMORE MOUNTAINS,

THE

RAMGHUR COAL FIELDS

AND ON THE

MANUFACTURE OF IRON,

&c. &c.

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THE accompanying Reports were found among the papers of the late Mr. Williams, whose sudden decease took place in November 1848, in consequence of an attack of jungle fever. Mr. Williams was then engaged in the examination of the Coal Fields of Ramghur, one of the districts in the vicinity of Hazareebagh. These papers, though obviously only rough drafts of reports to be subsequently drawn up with greater care, contain much valuable information; all are consequently now published.

In correcting the MS. no alteration whatever has been made, further than the correction of what were obviously clerical errors : as it was considered much more desirable to retain the original phraseology and statements of the observer himself, than to attempt any alteration which might possibly convey an idea different from that originally intended. The Map which accompanies the reports has been carefully reduced, all compiled from the original surveys made under Mr. Williams' direction at the time of the Geological examination of the Country.

The MS. has been corrected, and the printing of these Reports superintended, by Mr. Oldham, Superintendent of the Geological Survey of India.

GEOLOGICAL REPORT

ON THE

KYMORE MOUNTAINS.

In accordance with the instructions contained in letters No. 1498, dated 22nd December 1847, and No. 3, dated 3rd January 1848, from the Under-Secretary to the Government of Bengal, I proceeded to the north-west margin of the Sone River, and arrived at Dearee on the 15th February following. From Dearee I reached Bucknor near Rotasghur in 2 marches, and forthwith commenced the examination of the rocks developed in this vicinity, especially those constituting the great escarpment, flanking the north margin of the above-named stream, which forms an abrupt precipice through the whole extent of this valley, nearly one thousand feet high, more or less as the case may be.

Before entering into any details, it is requisite here to premise that I made a hasty visit to this locality in June 1846; but from the want of travelling accommodation, and the rain having previously set in with its usual vigor, I could not penetrate into the interior; hence the examination

then made of the rocks composing the hills to the north and west of Bucknor, was but superficial. It is, however, important to remark that the general opinion entertained for several years was, that the rocks constituting the Kymore Range, belonged to the coal-measures, and as the lithological characters of the sandstones, reposing over a thick deposit of limestone developed at the base of the escarpment above alluded to, favored that opinion, I consequently felt anxious to explore the locality in order to set at rest all further doubt upon this important subject: with this object in view, I accordingly beg to submit the result of my observations through the Sone Valley and across the Kymore chain of hills.

Commencing in the immediate neighbourhood of Akburpore, the escarpment previously referred to is composed in the ascending order of a bluish grey argillaceous limestone, thin bedded, and possessing the same lithological composition as the lias limestone of Europe. The compact argillaceous beds are seen to alternate with thin partings of black and grey argillaceous shale and *white* beds of indurated argillaceous marl, to which the name of *chalk* has been erroneously applied; these calcareous accumulations compose Rotas Ghauttee for at least 600 feet above the base, where, be it observed, the lower beds are concealed by a thick

deposit of alluvium; but about ½ a mile to the east of Bucknor Indigo Factory, and opposite to a round isolated hill near the road-side, lower beds are however exposed, of a light grey and bluish colour, thick bedded and compact, and occasionally somewhat crystalline, and intersected by veins of white carbonate of lime of the purest description; these beds have been brought to the surface by a line of local disturbance, and are seen to dip north at an angle of 16° and south at 80°: the axis of elevation crosses the road, and is traceable for some distance to the north-east. The limestone beds are on the whole fairly exposed round the base and up the sides of the detached hill here referred to; but the summit itself is capped by a bed of sandstone, from 50 to 60 feet thick; this sandstone is of the same composition as that seen at Rotas Ghauttee. Notwithstanding the great thickness of calcareous rocks developed in this locality (700 feet), they are to all appearance devoid of organic remains.

Having been informed by Mr. Sweetland that he had discovered a bed of coal on the west side of Raj Ghauttee, about 3 miles to the west of Akburpore, I proceeded to the spot and examined the whole of the rocks seen from the alluvial flat, to that part of the great escarpment which is perfectly vertical, and may be truly termed nothing else than a wall of sandstone several hundred feet high. The fol-

lowing is the description of beds here developed in the ascending order; namely, thick bedded siliceous sandstones, coarse grained, and occasionally containing white pebbles of quartz about 600 feet thick: next to these rocks there are black and grey argillo-arenaceous shales, containing thin bands of arenaceous rock, thickness 300 feet. On the top of the shale above-mentioned there occurs a bed of *black* argillaceous shale, three feet thick, rather soft and decomposed, containing nodules of iron pyrites, from the decomposition of which a white and yellow efflorescence exudes; this bed of carbonaceous shale, it appears, has been mistaken by Mr. Sweetland for a bed of coal, or at least he has attempted to make it appear that coal does occur on the north side of the Sone River, and that too in the immediate vicinity of Rotasghur, which is manifestly not the fact.

The limestone observed at Rotas is wanting to the west of Raj Ghauttee; it has in my opinion been cut off by a fault, a down-throw to the westward; there is consequently a greater thickness of sandstone here developed than at Rotas Ghauttee. This view is fully borne out, for while marching from Akburpore to Tura, 15 miles to the westward, the same description of limestone is again observed to occupy a narrow belt of low land near the village of Tipoh. The area here

exposed is but small, notwithstanding there are substantial reasons for concluding, as will be shown in the following pages, that these calcareous rocks extend through the Sone Valley to the westward, and along both margins of this stream.

It may be interesting to mention that close to the thin bed of carbonaceous shale adverted to in the last paragraph, there occur two large masses of white limestone (travertine), several tons in weight, reposing on large fragments of loose sandstone, which have fallen at some period or other from the escarpment. This limestone contains the impressions of leaves of the surrounding vegetation, consequently it must be classed as a modern deposit, probably coeval with the kunkur of Bengal, which it somewhat resembles in colour, but its composition is different, inasmuch as it contains on the whole considerably less argillaceous matter. These calcareous accumulations, which are several hundred feet (about 600) above the Sone, were in my opinion deposited from water percolated through the sandstone escarpment above, charged with carbonate of lime, the necessary carbonic acid being derived from the atmosphere and the surrounding vegetation.

At Tura information was brought by the zemindar, that there was no road on the north side of the river to the westward; it was, therefore,

deemed advisable to re-cross the Sone opposite this village, where it is much narrower than at Dearee; it nevertheless took a whole day to get the carts and baggage over, the sand being much looser, and the channel was found to be little else than quicksand, and the water was too deep to allow laden carts to ford it; the elephants had considerable difficulty to get over with the tents, hence all the baggage and stores had to be conveyed to the opposite side, in a small leaky boat.

We encamped for the night near the village of Soneporah: the Rajah of the same name lives at this place, and was anxious in his inquiries as to the object of visiting his territory; after being informed, he appeared somewhat pleased, and directed his people to supply the Camp with everything required. On the following morning we commenced marching in the direction of Kossderah, but before proceeding two miles we had again to descend into the bed of the Sone, in consequence of a deep narrow nullah impeding further progress along the margin; however, after sloping down the margin the carts were all got down, and after three hours hard work they were hauled through the sand, and got up on the opposite side into a narrow strip of cultivated land.

Near Huriapore, beds of argillaceous limestone are exposed on the surface, dipping north at

an angle of 20°; these are lithologically the same as those on the north side of the river, and in all probability identical, as in both localities they support rocks constituted of the same mineral ingredients. The limestones here adverted to are flanked on the south side by a low range of hills, somewhat scantily covered with vegetation, and composed of stratified rocks of an altered character, which are exceedingly hard and alternate with broad bands of *felspathic* rocks passing into *syenite* of a dirty colour, and thin bands of indurated shale, which occasionally assumes the character of Egyptian jasper; these beds invariably cleave into rhomboids and parallelograms. Calcedony is also found in these hills, but always developed in the form of drifted pebbles. The whole mass of rocks constituting the hills flanking the Sone River, dip north at angles varying from 20° to 26°.

Between Kossderah and Panchdoomrah, there are thick beds of siliceous rocks exposed on the surface, and differing essentially from those above noted: they also dip north at an angle of 30° to 40°. These beds would seem to occupy an intermediate position between the limestones developed near the village of Huriapore and the altered rocks to the south of them; and still further west (about 2 miles before reaching Peparah), there occurs a thick bed of coarse conglomerate, containing pebbles

of white quartz and red cornelian, cemented in a quartzose and *felspathic* base: beneath this conglomerate there are thick beds of greenish grey argillaceous shale, slightly micaceous, but destitute of all trace of organic remains: still lower in the series there are several alternations of black, grey, and brown siliceous rocks, shales, and thin beds of flaggy sandstones passing into arenaceous slatey beds of a dark grey colour. These rocks have been thrown into a series of trough-like undulations, sufficiently marked to be denominated anticlinal and synclinal lines; the northern declivities dip at an angle of 18° to 30°, and the southern from 25° to 40°. In the descending order these beds pass into altered rocks, principally composed of syenitic looking bands and indurated shales, intersected by veins of white crystalline quartz rock, the whole plastered over with drifted pebbles of rounded quartz, calcedony, jasper, and red cornelian.

The rocks noted in the last paragraph evidently bear off to the south-west, for in the neighbourhood of Chachnee thin siliceous rocks, of the same composition as those developed in the vicinity of Peparah, are observed in the bed of the Sone itself, where they are seen to extend quite across the stream and form rapids. In this part of the valley there appear to be marked indications of a good deal of local disturbance; in fact, the beds

are seen to dip both north and south, at angles varying from 60° to 70°, and in the bed of the nullah on the west side of Chachnee a fair section of the beds is exposed, exhibiting the angle of inclination to be all but vertical,—the line of strike running nearly parallel with the Sone River, and the most prevalent colours developed being black, snuff-brown, grey, and occasionally red. Proceeding from Huldee to the westward, these rocks are found to occupy but a narrow belt on this side of the Sone, where they are flanked on the south side by a range of broken and occasionally detached conical hills, constituted of grey crystalline limestone, which dips north at an angle of 60°. These calcareous beds are of the same colour and character as the lower beds of limestone developed on the north of Bucknor ; they extend in a westerly direction bearing to the south of the village of Kotah. On the north of this belt of calcareous rocks, there is, in the bed of the Kunor Jour, a well-exposed section of siliceous rocks of the same lithological composition as those observed to the eastward; they dip north at an angle of 70°, and must be regarded as higher in the series than the limestone, which is non-fossiliferous, and it is my further conviction, a different mass to that seen at Rotasghur, and of course lower in the series than the siliceous rocks and grey shales

developed in the vicinity of Peparah and Partee. This view is fully supported by the local fact of the existence of the argillaceous limestones on the opposite side of the river, where they are seen at the base of a subordinate eminence thrown off from the main escarpment, lying to the north of the village of Kunch; but it is proper nevertheless to state, that only a small part of the upper beds are there exposed, the locality being plastered over with a thick deposit of alluvium containing calcareous nodules in great profusion.

While marching from Kunch to Sulkum *viâ* Chitore Pass, our progress was impeded, in consequence of the broken and jungly nature of the country, for a period of three days: it is hardly possible to conceive a country presenting greater difficulties for marching, in any part of India; indeed, along the whole distance from Kunch to Sulkum (7 miles) the country presents nothing but rocky passes, deep ravines, surrounded in every direction by deep hollows, scooped out of the alluvia. The road shown in the old maps is impassable for carts; I had, therefore, to convey all the baggage and stores on elephants and bullocks to the village of Sulkum. Notwithstanding this, there were still considerable difficulties to be removed before the empty carts and hackeries could possibly be hauled through the pass and across the different nullahs.

The rocks exposed in Chitore Pass are principally constituted of thick bedded sandstones, and black and grey argillo-arenaceous shales, similar to those seen near Raj Ghauttee. Proceeding from south to north, these beds are seen in the first instance to dip in that direction at an angle of 5° to 8°, but after crossing the Gunghur Nullah they are seen to dip in the opposite direction, forming the southern plane of an anticlinal line, observed in the main escarpment to the eastward; it is also beautifully developed in the hill upon which the old fortress of Bidseeghur stands. From Sulkum to the village of Meerkoondah there is nothing to be seen worthy of observation; but close to the village last named, and in the bed of the nullah on the north side of it, the argillaceous limestones, which have been shown to extend under the escarpment from Rotas to Kuneh, are then brought to the surface 10 miles further north, and there can be no doubt whatever as to their identity; they dip north at an angle of 10°, and can be traced up to the base of the ridge of high land lying between Meerkoondah and Aky Pouah Ghauttee. The rocks composing the Ghauttee itself correspond on the whole with the section developed at Rotasghur, and they are well exposed from the base to the table-land at Romp; this ascent, which is 1,000 feet above the river, exhibiting

consecutively thick and thin beds of sandstone, together with indurated beds of arenaceous shale of a grey and brown colour, occasionally stained red. At the top of the first ascent, where the track is both narrow and dangerous for cattle, the rocks for a short distance appear to be vertical, but on a close examination they will be found to be the contents of a line of fractures which crosses the range at this point; the beds both north and south of this line of faults dip north at an angle of 10° to 12°, but after ascending the table-land beyond the second steep ascent, the angle of inclination becomes gradually less, until they finally assume a horizontal position.

In the vicinity of Romp there is a fair exhibition of quartzose sandstones, colored white, grey, yellow and brown; these beds, when viewed on the large scale, have a manifest tendency to dip north. To the eastward, rocks of the same lithological construction are clearly traceable to the village of Pursoonah, where they dip north at an angle of 10°, but on proceeding to the south they gradually become less inclined, and before ascending the hill upon which the old fortress of Bidseeghur stands, they are perfectly horizontal. The patch of table-land inclosed within the fort walls forms the centre of the anticlinal line previously alluded to, and is the most

prominent object in the locality; it can only be approached on the north-west side, by a rugged and broken path, over huge blocks of sandstone, over-grown by thorns and bamboos; the west and east sides are protected by vertical walls of sandstone, at least 1,200 feet above the base of the hill; the south side is connected with the main range by a narrow ridge densely covered with wood. There are within the fortress two large tanks, cut in solid sandstone, a task of considerable labour without the aid of powder. These reservoirs, notwithstanding their great height above the surrounding country, contain all the year a large supply of the most delicious water. The view from this eminence to the south-west is exceedingly bold and picturesque, and the observer, while contemplating the wild scenery of the surrounding neighbourhood, cannot fail to be struck with the enormous amount of consolidated mineral matter periodically scooped out from the valleys below by denudation.

From Romp to Shawgunge the surface of the country is plastered over with a thick deposit of alluvium, which also extends over a considerable area towards the east and north, and north of west, beyond the village of Ghorawul, but to the north of Peyr the grey and brown sandstones are again developed and nearly horizontal; these conditions are

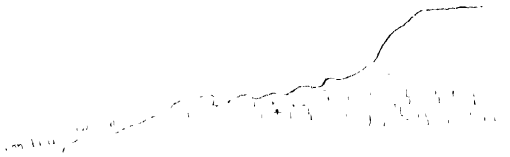
seen without the slightest variation or change beyond the Dwarkha Nullah. Near the village of Umoee, there exists a small patch of iron conglomerate (similar to that seen in Bengal), reposing on the sandstones. The soil in the vicinity of this conglomerate is of a red colour, and of an arenaceous character ; the subjacent sandstones are also stained red, on the north side of Umoee, and have a slight tendency to dip north. About two miles further north the sandstones dip north-east at an angle of 10°, and only 500 feet to the north of this place they are again horizontal, and continue so all the way to Goretuttwah : the same lithological structure is also persistent.

From Goretuttwah the descent of the Kymore mountains on the north side becomes more marked and rapid, and the section of the country exhibits nothing but one mass of sandstone to the alluvial flat near the base of Pouah Ghaut. The rocks composing the ghaut itself are horizontal, fine and coarse grained, of a light grey salmon color.

From Mirzapore, I again re-crossed this range of mountains, *viâ* Tara Ghaut, proceeding from thence to Lolgunge, Hullcah, Adaisir Fort, and thence to Pursea. Along the whole chain, the sandstones correspond in a great measure with those seen at Raj Ghaut, 100 miles to the westward.

The Ghauttee on the south side of Pursea is entirely composed of thick bedded sandstones, dipping north 8° to 10°; and about 20 chains to the south of the escarpment, in the bed of a nullah, the grey argillaceous limestones are again exposed, under similar circumstances to the limestone beds seen near the village Meerkoondah, at the base of Aky-Pouah Ghauttee; the beds above-noted undulate towards the Sone River, where the lower beds are well exposed close to the margin of this river, and in contact with black argillo-arenaceous shale, dipping 35 east of north, at an angle of 8° to 12°; this shale contains siliceous concretions 6 feet diameter, 2 to 3 feet thick, somewhat flattened on the top: the section here exposed exhibits a thickness of at least 500 feet. Notwithstanding this, the Singrowli Coal Company's Agent was sinking a shaft 50 feet under the limestone above alluded to, and nearly at the top of the black shale, in search of coal, although there was nothing indicative of the presence of coal to warrant such a conclusion. It may be proper further to mention, that the existence of black shales, associated with sandstones, is no indication of coal, or even of coal-measures. Carbonaceous rocks of a similar character developed near Bidseeghur, no doubt led to the erroneous conclusion that a coal-field existed there; however, carbonaceous rocks are common to several

suites of rocks of an earlier and also of a more recent date than those to which the term coal-measures has been applied. The following figure will show the actual position of the beds alluded to, on the west of Burdee.



Having now crossed the Kymore Mountains three times, and in different directions, without seeing anything to justify my concluding that any coal existed in them, I proceeded to Chunar, and made several excursions to the interior, without seeing any change in the composition of the rocks : hence it is unnecessary to repeat here a description of the same character of rocks as those seen to the south, which are fully described in this report. From Chunar I marched along the north ghauts, passing through Boderah, Chikia, Hilleah, Cheynaparah, and found the hills composed of the same description of sandstone seen on the south of Chunar, which in my opinion are

the same beds. On the north of Ramnugur, near to where the range makes a sharp bend to the south, there is seen a small patch of argillaceous limestone, cropping out between the alluvium and the sandstones. Between this limestone and that seen on the south of Undapore, there must be a fault, otherwise the limestone last mentioned could not appear on the surface so far south, and beyond the point where the upper beds are seen on the surface dipping south at an angle of 6°. The limestones at Undapore also dip south, but do not extend to the west more than 50 yards: to the eastward, these beds extend for a short distance beyond the village of Seyrah, where these calcareous beds are worked and burned into lime. On the south of Seyrah the limestones extend 150 yards through the pass, but on the east side they are cut off by a large fault, seen in the hill on the west side of Bogwanpore. This hill exhibits precisely the same section in detail as previously observed on the south in the Sone Valley. To the east of Bogwanpore, near the village of Nowpatta, the same argillaceous limestone, with its white marly partings, is again seen to partially ascend the side of an isolated hill in advance of the main range, the top of this eminence being covered by sandstone, which here dips to the south-west at a small angle ; this limestone evidently appears to me to

be at no great depth from the surface on the north side of the Kymore Mountains, and it is not improbable it might be found at Chunar at a workable depth; on the south side, in the Sone Valley, it has been shown to exist at the base of the sandstone for a distance of more than 100 miles, and always presenting the same mineral character and total absence of organic remains.

RAMGHUR COAL-FIELDS.

The coal-fields to be described in the following reports are situated within the district of Ramghur; they are three in number, comprised between 85° and 86° east longitude, and 23° 30′ and 24° north latitude. Although it will be shown that these coal-fields formerly belonged to one and the same deposit, and formed part of the same great chain of carboniferous rocks developed lower down the Damoodah Valley, they will, as a matter of course and convenience, require distinct names. On a reference to the accompanying map, it will be seen at a glance, that the survey commences on the east near the junction of the Damoodah River with the Koonar Nuddee, a considerable stream during the rains, being 5 to 600 feet broad: it drains the hilly country lying on the north of the Old Trunk Road to Hazareebagh. Two miles and a half from the confluence above alluded to, the Koonar joins another large stream called the Bocahroh Nuddee, which is quite as large as the

Koonar itself. The last-named stream bears off towards the westward, and the Koonar to the north and the west of north; the latter drains the chain of hills surrounding the table-land on the east, and the former nullah traverses the eastern coal-field for a distance of at least 27 miles, forming a separate valley between the chain of hills just alluded to and the Damoodah River, in which that coal-field is developed; therefore, the name Bocahroh will be applied to the coal-field extending from the confluence of the Koonar with the Damoodah, in a westerly direction, to the village of Indrajarbah, where the coal-measures constituting this field terminate.

The next coal-field which I have to place on record is much smaller than the one previously alluded to; it is situated on the south side of it, in the Damoodah Valley, and only distant 5 miles to the east from the old fort of Ramghur. And in order not to confound this small field with the great coal district examined last year in the same valley, it is therefore deemed advisable, from the local circumstance of this deposit being near to the ancient seat of Government of the Rajahs of Ramghur, to apply the name of Ramghur coal-field to it.

The other coal-field is 11 miles to the south of Hazareebagh, west of the Bocahroh field, and only separated from it by a narrow chain of hills com-

posed of crystalline rocks, about 6 miles broad in the aggregate. This field is also traversed by a large river called the Hoharoo Nuddee, a considerable tributary of the Damoodah, after which it will henceforth be called and described in this report.

THE BOCAHROH COAL-FIELD.

This coal-field is bounded on the north side by a chain of hills, the higher peaks of which attain an altitude of about 3,000 feet above the sea, but the coal-measures, generally speaking, occupy comparatively low undulating land, with the exception of that part constituting Loogoo Hill, which is entirely composed of coal-measures standing out in bold relief to the south of the main chain. The north and south sides of this gigantic hill are nearly vertical, composed of sandstone, shale, and coal seams, exhibiting in one view a mass of carboniferous strata, at least 1,500 feet above the bed of the Bocahroh Nullah, and the adjacent streams. This hill is one of those beautiful examples reminding the passing traveller of the ravages committed by denuding causes, and its present bold and broken aspect fully demonstrates that an enormous mass of coal-measures has been removed from this locality by the agency of water, which mass once extended in solid sheets over a more considerable

area, and probably attained a greater thickness than the measures composing Loogoo Hill, which are nearly horizontal. This circumstance, together with other important facts, manifestly proves that these measures have not been "contorted, or projected upwards to the surface, forming mountain strata," but are simply a mass of strata which has resisted the action of moving waters when this land, together with Central India, was progressively elevated from the bosom of the ocean. While surveying the external physical aspect of a hilly country, it too often happens that little or no attention is paid to the effects of denudation which have, in conjunction with atmospheric causes, materially modified the surface of the crust of the globe, adapting it as a fit abode for the habitation of man, and to such causes the existing features of this country must be mainly assigned. The value and importance of other local phenomena must not, however, be overlooked during the examination of any country, and the observer must ever be on his guard to attach due weight to the subject of lines of fractures, which have played an important part by fracturing large sections of a country, and bringing rocks of different geological ages into juxtaposition with each other. That phenomena of this character have occurred in the district will be fully demonstrated in the following pages.

The north boundary of this coal-field exhibits a beautiful example of the grand result produced by a fault which traverses the coal-measures of this field for a distance of 30 miles, and it will be also shown that this line of fracture does not stop here, but crosses a range (subordinate to the main range) of crystalline hills, and intersects the Hoharoo Coal-field just in the same manner as it does the district under consideration. To the east of Goomeah, this coal-field has, by a combination of causes produced by both denudation and faults, been reduced to an insignificant compass, and presents appearances as if the north and south boundaries would intersect each other at no great distance to the eastward. Near the junction of the Koonar with the Damoodah, the coal-measures are only 2 miles broad, but on the meridian of Goomeah this field, however, swells out in a distance of 6 miles, to 4 miles in breadth, and appears to increase in a westerly direction up to the base of Loogoo Hill. Near Decassarum this field is again contracted to little more than $2\frac{3}{4}$ miles from south to north; from this point to the westward the coal-field again expands to $6\frac{1}{2}$ miles, and continues so all the way to the great western fault, which cuts off the coal-measures in a north and south direction.

The southern boundary of the coal-field, near Khottorah, is close on the north margin of the

Damoodah River, and continues to run nearly parallel with this stream for a distance of 8 miles to the westward, where the line makes a sharp bend to the south; the coal-measures along the whole of this line are seen in juxtaposition with the crystalline rocks, a proof that the southern boundary is a great fault with a general line of bearing east and west. Near the village of Cherhgaongwah this fault, however, makes a bend to the north of west for the village of Decassarum, where the junction of the coal-field and the crystalline rocks has been determined with the greatest accuracy. From Decassarum to the westward this fault bears off to the south of west toward Moorpha, and close to the village of Khurjuah it is joined by the great western fault previously alluded to.

The northern boundary has already been shown to be a line of fracture; it cuts off the coal-measures on the south side of Indrajarbah; from thence it extends along the base of the chain of high land flanking the coal-field on the north in an easterly direction, passing 30 chains on the north side of Polehomon, and subsequently to the north of Karreepany; from this village it keeps almost a straight line, and passes between the villages of Dorredagh and Watchoh to the south side of a small hill, on the north of the village of Goomeah. About a mile to the east of this hill, this fault crosses the Koonar

Nuddee, keeping on the north side of it to the bend, where this stream passes through a lower range of hills in a south-east direction. From this point it takes a somewhat curved direction, and passes through the village of Gobinpore, on the south side of the Semaphore Tower, and no doubt extends in an easterly direction far beyond the point shown on the accompanying map.

The lowest beds of this field are to be seen in the bed of the Boodu Nullah, on the south side of the village of Jarbah ; they are thick conglomeritic accumulations from the crystalline rocks: these beds of conglomerates differ essentially from anything before seen associated with the carboniferous rocks, being composed of enormous boulders of granite, some of which measure from 3 to 10 feet diameter; these are also intermixed with large boulders of white quartz, chlorite rock, hornblende, and mica schist. It is impossible to look at such immense masses, which bear strong evidence of having been rounded by attrition before they were deposited in the coal strata, without manifesting some degree of surprise and astonishment. These large boulders are mostly near the base of the coal-measures, and it may be interesting to state that round boulders of granite 10 feet diameter would weigh nearly 40 tons, and that to move such a body there must have been a

good deal of commotion and agitation then existing in the vicinity from whence such masses had been torn from the parent rocks. Our present notions of rivers would hardly justify the conclusion that these boulders had been transported by the agency of river-currents; it would be more reasonable to suppose that this district was not far distant from the line of sea-coast of the time, and that these gigantic boulders had been rounded by the dashing of sea-breakers near clefts on the margin of it. We have no reason to surmise that these boulders had been transported from any great distance, especially as the surrounding district is entirely composed of rocks of the same lithological composition, and from which no doubt they were derived in the manner previously supposed. These conglomerates alternate with greenish grey beds of shales and thin beds of fine-grained sandstones, and have a developed thickness of 900 to 1,000 feet under the lowest known bed of coal.

The lower coal-bearing measures of this district also alternate with thick beds of sandstone, subordinate beds of shale, and beds of small conglomerates composed of rounded white quartz pebbles, but quite different to the boulder-formation above alluded to. These measures are identical with the same description of beds observed in the Damoodah and Adji

great coal-field, and they occupy the same relative position in both localities: and it is gratifying to observe, as will be shown in this report, that this coal-field occupies an area of 150 square miles, contains the black and grey shale with the carbonate of iron, and in beds still higher in the series corresponds on the whole with beds occupying a similar position in the Damoodah great field, and to which I believe them to be analogous, and to occupy the same geological parallel in both localities respectively.

The first workable seam of coal, observed on the western end of the coal-field, is exposed in the bed of the Bocahroh Nullah, and two miles to the east of the village of Indra, dipping north at an angle of 6°. This coal is covered by a bed of conglomerate, containing white quartz pebbles, and occasionally rounded boulders 6 inches diameter, beneath which the following beds are seen in the descending order: black carbonaceous shale, 2 feet 6 inches; coal superior, 4 feet 6 inches; black-rock, 1 foot; inferior slatey coal, 4 feet; conglomerate, 18 inches; slatey coal, thickness not seen. These beds are at no great distance to the north of the places where the coal crops on the surface become horizontal and subsequently rise in the opposite direction. The bed of superior coal above noted possesses the same concretionary structure as some

of the coal-beds developed at Taldangah, in the Damoodah Coal-field. The concretionary nodules procured from these beds have been erroneously supposed to be drifted boulders of coal of a prior origin, which is manifestly not the case: it is in fact a structure common to the coal itself, and a peculiar characteristic of most of the superior coal seams belonging to the lower measures. I have also seen the same structure in coal-beds in other parts of the Damoodah field, which are of the most inferior description, containing fully 50 to 60 per cent. of ashes.

On the south side of the out-crop of the seams of coal just alluded to, another bed of inferior slatey coal, 4 feet thick, is seen in the bed of the Boodu Nuddee, a tributary stream of the Bocahroh ; these beds dip at an angle of 6°, and conformably with those seen in the river last mentioned, and are lower in the general section. About 400 yards higher up this nullah, a thin bed of inferior coal is exposed to view, only 18 inches thick ; this seam in my opinion is unequivocally the lowest bed in this coal-field, beneath which the section of the measures are on the whole fairly exposed down to the great boulder conglomerate, previously mentioned.

To the eastward the surface of the coal-field, generally speaking, is extensively covered with a

deposit of alluvium and with jungle, but nevertheless out-crops of coal are to be seen in the bed of the larger streams, more especially in the Bocahroh and the Chootooah Nullahs, and their tributary streams. On the north of Seyho the following beds are developed in the last-named stream and along its margin :—

Descending.

		Ft.	*In.*
1.	Grey shale and sandstone in bands...	30	0
2.	Yellow sandstone	1	6
3.	Grey shale argillaceous	5	0
4.	Grey and yellow sandstone	2	0
5.	Grey argillaceous shale	30	0
6.	*Coal*, superior	3	0
7.	Grey micaceous sandstone	8	0
8.	Grey shale	1	0
9.	Brown micaceous sandstone	2	0
10.	Brown and grey arenaceous shales, with impressions of plants and bands of ironstone	5	0
11.	Grey micaceous sandstone	6	0
12.	Grey argillaceous shales	4	0
13.	*Coal*, superior	4	0
14.	Grey micaceous sandstone, with stains of coaly matter	70	0
15.	Grey shale	5	0
16.	Brown sandstone	3	0
17.	Argillaceous shale	3	0
18.	*Coal*, slatey and inferior	4	0
19.	Brown and grey sandstone and shale alternating...	20	0
20.	Grey and brown fine grained sandstone, with large boulders of white quartz in the bottom beds ...	50	0
21.	*Coal*, superior	6	0
22.	Brown and grey sandstone micaceous	40	0
23.	*Coal*, superior	3	0

		Ft.	In.
24.	Grey arenaceous shale, micaceous	12	0
25.	Grey sandstone, micaceous	6	0
26.	Grey argillaceous shale...	3	0
27.	*Coal*, superior	0	10
28.	Black and grey argillaceous shale	6	0
29.	Grey sandstone, with grains of coal	2	0
30.	Shale	0	6
31.	Sandstone	1	6
32.	Argillaceous shale	1	0
33.	Sandstone	1	0
34.	Grey argillaceous shale, with nodules of ironstone...	3	0
35.	Sandstone, grey	2	0
36.	Grey argillaceous shale	2	0
37.	Grey sandstone	3	0
38.	Grey argillaceous shale	3	0
39.	Sandstone	2	0
40.	Grey arenaceous shale	2	0
41.	Sandstone	1	0
42.	Sandstone and shale alternating	20	0
43.	Grey argillo-arenaceous shale, with bands of ironstone	10	0
44.	*Coal*, superior	5	0
45.	Grey underbed, with impressions of plants ...	4	0
46.	*Coal*, ...	0	6
47.	Sandstone	0	6
48.	Grey argillaceous shale	2	0
49.	*Faulty ground angle of dip* 60°		
50.	Sandstone	50	0
51.	Sandstone and shale	2	0
52.	Sandstone	6	0
53.	Argillo-arenaceous shale	10	0
54.	Sandstone	5	0
55.	Argillaceous shale	6	0
56.	Shale and sandstone	20	0
57.	Sandstone	20	0
58.	Shale and bands of sandstone	10	0
59.	Grey shale	1	0

		Ft.	In.
60.	*Coal*, superior	2	0
61.	Fine grey grained sandstone	30	0
62.	Grey argillaceous shale	20	0
63.	Brown sandstone	10	0
64.	Black shale	2	0
65.	*Coal* inferior	2	6
66.	Grey arenaceous shale	4	0
67.	Brown-grey argillaceous shale	20	0
68.	Grey sandstone	60	0
69.	*Coal* superior	4	0
70.	Grey underbed	3	0
71.	Sandstone with concretions of ferruginous rock ...	30	0
72.	Grey argillaceous shale	6	0
73.	Sandstone	3	0
74.	Grey shale	20	0
75.	Brown sandstone	20	0
76.	Shale and sandstone	20	0
77.	Grey sandstone	30	0
78.	Sandstone and shale	100	0
79.	Argillaceous shale with ironstone nodules	0	0
80.	Sandstone	0	0

The above section embraces a total thickness of 917 feet and 10 inches, of which there are 11 seams of coal, having an aggregate thickness of 30 feet and 10 inches; of this quantity we have 20 feet and 10 inches of workable coal, in 6 separate beds. These beds dip to the south-west, at angles varying from 10° to 60°, but near the junction of the Chootooah with the Bocahroh Nullah, two beds of coal, and their associated rocks, dip to the north, being nearly in an opposite direction.

In the bed of the Bocahroh, nearly a mile on the south side of Seyho, the coal-measure sandstones,

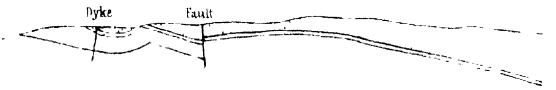
shales, and beds of coal, are seen cropping on the surface, with a dip of 14° bearing 80° west of south. Respecting the exact position these beds occupy in the general section of the coal-field, I cannot, for many considerations, come to a definitive conclusion, there being many difficulties to surmount, in the examination of unworked coal-fields, in India, and few geologists in Europe would like to run the risk attending the laborious duties required of a geologist in India, which are totally distinct from what is required in England, where geologizing is one of the most delightful occupations a man can follow. In India it is attended with fatigue, exposure to the climate, and the man who undertakes the duty becomes at once a daily prey to ferocious wild animals. However, the following section of the measures above alluded to will throw some light on the composition of this part of the coal district :—

Descending.

		Ft.	*In.*
1.	Brown sandstone micaceous	20	0
2.	Grey shale	1	0
3.	Grey sandstone	8	0
4.	*Coal*, ...	3	0
5.	Grey underbed with fibre-like impressions and of leaves, ...	10	0
6.	Sandstone, ...	0	8
7.	*Coal*, slatey and inferior, ...	1	0
8.	Grey arenaceous underbed,...	1	0

		Ft.	In.
9.	Grey sandstone, ...	3	0
10.	Black shale, ...	2	0
11.	*Coal*, superior, ...	1	4
12.	Grey micaceous sandstone, ...	1	0
13.	Grey shale, ...	0	6
14.	*Coal*, ...	0	6
15.	Shale parting, ...	0	6
16.	*Coal*, ...	2	0
17.	Grey argillaceous underbed, ...	3	0
18.	Arenaceous shale, ...	3	0
19.	Shale and sandstone,...	6	0
20.	Sandstone, ...	12	0
21.	Grey arenaceous shale and bands of sandstone, ...	3	0
22.	Yellow sandstone, ...	3	0
23.	Grey argillaceous shale, ...	6	0
24.	*Coal*, superior and concretionary, ...	5	0
25.	Grey shale, underbed, ...	8	0
26.	Sandstone, ...	1	0
27.	Grey shale arenaceous, ...	3	0
28.	Grey micaceous sandstone, ...	12	0
29.	*Coal*, ...	4	0
30.	Grey and black underbed, ...	4	0
31.	Brown sandstone, ...	6	0
32.	Brown sandstone and shale,...	8	0
33.	Black shale, ...	4	0
34.	Brown sandstone conglomeritic	1	6
35.	Black and grey shale, ...	1	0
36.	*Coal*	3	0
37.	Underbed, ...	3	0
38.	Sandstone and shale, ...	40	0
39.	Sandstone, with occasionally dispersed boulders of white quartz, ...	60	0
40.	Sandstone, with occasionally thin beds of shale, ...	20	0
41.	Shale with argillaceous sandstone	4	0
42.	*Coal*, ...	2	0
43.	Grey underbed, ...	3	0
44.	Sandstone, (thickness not seen.)		

Near the seam of coal No. 42 the measures exhibit an anticinal line 300 feet broad ; the rocks dipping respectively to the east and west, in the first instance at 6°, subsequently they rise on the east of the fault at a distance of 300 feet, and dip west 4° ; here two more beds of coal appear on the margin of the river—the upper bed is 3 feet and the next 2 feet, with a bed of shale 2 feet high between them ; the lowest bed rolls to the east at an angle of 10°, and at a distance of 100 feet it again appears on the surface, dipping west at an angle of 12°: on the south side these beds are intersected by a trap dyke, which does not appear to produce any difference in the position of the beds, beyond what arises from the undulations alluded to. The following figure will aid in making the above description more intelligibly understood :



The measures detailed in the last section, contain no less than 11 beds or distinct seams of coal,

varying in thickness from 6 inches to 5 feet, having an aggregate thickness of 26 feet and 6 inches. Some of these beds are thin, and of an inferior quality; but still there are others quite thick enough to be worked, and of a quality calculated to yield fuel of a superior character. In the same vicinity other seams of coal have been seen, namely, on the west of the village of Rohan a bed of coal crops on the surface; this coal is nearly horizontal, and associated with black and grey argillaceous shale, containing clay, iron stones, and, in the bed of the Bocahroh, below its junction with the Chootooah Nullah, two seams of coal are developed under favorable circumstances for being worked. On the north side of the village of Kareepance, two more beds are seen dipping south, at an angle of 14°: the first bed is exactly 700 feet from the village last named; it is 6 feet thick and the coal itself is of a good quality. The other bed is 600 feet further north, reposing on a bed of conglomerate, and covered by shale and thick beds of sandstone; this bed is lower in the series than the one previously mentioned, and no great distance from the great north fault. From what has already been stated it will appear very manifest that coal abounds in this part of the field, and from what has been ascertained of the quality of the different beds on the out-crops, I shall be fully jus-

tified in concluding that fuel of a superior description could be obtained in any quantity from this locality.

To the east of Loogoo hill, in the bed of the Durdurhwah nullah, and close to the junction of the Meersabad with that stream, the coal-bearing strata are nearly vertical. In this locality two seams of coal are exposed in the bed of the Durdurhwah; they are separated from each other by thick beds of sandstone, and subordinate beds of shale, having an aggregate thickness of 300 feet: the lowest seam of the two is only two feet thick, and the thickness of the other could not be ascertained, in consequence of too much water being in the river, which concealed the greater part of the coal itself. The measures inferior in position to the seams here alluded to, are on the whole fairly exposed to the great boundary south fault; these rocks are constituted of shale, sandstones and beds of conglomerates, and are fully 2,000 feet thick, from the two-feet seam of coal above-mentioned to the junction of the coal-measures with the crystalline rocks. Although only two beds of coal are seen to crop on the surface, it is more than probable that several other beds occur in this part of the district; but the high angle of inclination of the measures associated with the coal, as well as that of the coal itself, will be a serious obstacle in the way of work-

ing them, which could only be accomplished by adopting the same plan as that generally practised for working metallic veins; this however will hardly be required in India, where we have so much coal more favorably posited for being excavated on an extensive scale. On tracing the rocks noted above towards the east, it has been found that the high angle of dip invariably observed between Jerwah and Kirawahtan, diminishes very rapidly between Jirhkee and the Damoodah river, where the angle of inclination only averages from 12° to 16°. The maximum angle was obtained close to the south or boundary fault, and on the same line of strike as the vertical beds previously mentioned, which are only three miles to the westward.

On the north of the village of Jirhkee, there is a marked indication of an out-crop of coal, the angle of dip of the subjacent beds will not exceed 12°; this out-crop manifestly appears to be on the same line of strike as the coal seam developed on the north side of the village of Mahleebahud, which occupies the centre of a trough-like depression, with the truncated edges dipping both north and south.

Proceeding to the north side of the field in the eastern end, the coal strata are invariably found to dip south at an angle of 14°; but near the village of Goomeah the beds dip south-west at 18° to 20°, and to the west of Watchoh the angle of incli-

nation is augmented to 40° bearing south. Near the last-named village two seams of coal are exposed on the surface, at no great distance from the great north fault; and again on the north-east of the village of Lalkootah, in the bed of the Koonar, a thick bed of coal occupies a similar position in the series, and dips south at an angle of 18°. In the Koille Nuddee, a tributary of the Koonar, a thick seam of coal occurs under similar circumstances, together with other indications.

Having made the entire circuit of this coal field, and before concluding this sketch, it appears essentially necessary to observe that it is exceedingly probable that several of the beds of coal described in the preceding pages may be found hereafter to be identical; moreover, it is requisite here to state, that from the augmented knowledge acquired of the constitution of the coal districts developed on the south west frontier of our Indian Empire and judging from the analogy existing between the coal-fields here alluded to, and the Damoodah and Adji great coal-field, there cannot be a shadow of doubt but there still remains concealed beneath the superficial covering of alluvium more than double the number of the seams of coal recorded in this report. To work out these maiden coal districts in geological detail, would occupy more time, and incur a larger expense by sinking experimental shafts than would be justifi-

able under existing circumstances ; but nevertheless, the facts collected and detailed in this report will be quite sufficient to convince government that the coal-fields developed on the south-west frontier are exceedingly interesting in a scientific point of view, and manifestly invaluable in a national point of view, and will ere long be the medium of introducing various branches of industry amongst the native community, and extending the commercial intercourse of this country with other nations, on a much larger scale, and more substantial basis than hitherto.

RAMGHUR COAL-FIELD.

This coal-field consists of an insulated basin of the subjacent members of the series of strata belonging to the carboniferous formation, the lowest beds of which are well exposed on the surface near the village of Poonoo, lying to the south of Lawaloung Koorakin Hill, and are principally constituted of rounded boulders of white quartz, gneiss, and other members of the crystalline formation ; this conglomerate is in fact perfectly identical with the great boulder conglomerate observed 20 miles to the westward near the village of Indrajarbah, which unequivocally demonstrates that the coal-fields on this frontier are but dis-

united parts of one great deposit, which have been separated from each other by great lines of fractures, and the mass of measures which once occupied the intervening areas, no doubt was removed by subsequent denudation. The boulder conglomerate has been observed to underlay the three coal-fields posited in the zillah of Ramghur, and evidently appears to be the lowest member of the coal strata in India with which we are acquainted. It is expedient here to mention that there is a marked distinction to be drawn between the boulder conglomerate and the conglomerate (pudding stones) associated with the coal-bearing measures, inasmuch as the latter rock is constituted of comminuted grains of sand and pebbles of rounded white quartz, and the former is characterized by being principally composed of large boulders, some of which are several tons in weight.

The conglomerate developed round the village of Poonoo is nearly horizontal, with little or no soil over it; but to the south of the village it dips towards the east of south at angles varying from 8° to 14°, and before reaching the banks of the Damoodah river, the coal-bearing pudding stones, sandstone and shales come in, and extend along both margins of the above-named stream, in the bed of which seams of coal are seen: and also about a mile to the north, another bed, lower in the series,

crops on the surface, dipping east of south at an angle of 10°; the beds here alluded to are of an inferior quality, and consequently of no great value; however, no doubt whatever can be entertained that better seams of coal occur in this field. I am led to this conclusion, from the analogy existing between the measures here developed and those existing in other fields in which coal of the most superior quality has been found. Notwithstanding this, the fuel contained in this field, cannot in any way be made available for any useful purpose, in consequence of its being situated in such an out-of-the-way place. It is quite out of the question to suggest any plan by which the coal could be conveyed over the adjacent country to any depôt on the Ganges or elsewhere at anything like a reasonable price; hence it would not, under the circumstances adverted to, be advisable to incur any expense whatever in making detailed researches in this field with a view of working the coal, while two maiden coal-fields exist on the north of it, in more accessible situations, which will be found fully equal to any contingency required.

However, for the purpose of geological science, it is advisable to enunciate the probable area occupied by this small field on the accompanying map: on the inspection of which it will be found to comprise about 10 square miles.

HOHAROO COAL-FIELD.

This coal-field is posited on the south of Hazareebagh station and south of the chain of hills flanking the plateau of table land composing the surrounding neighbourhood of the above-named station, and, generally speaking, it occupies the low land composing the valley through which the Hoharoo passes. On the south side of this field the coal-measures are also flanked by a chain of hills, which interposes between it and the Damoodah river; this range forms a continuous chain, nearly 2,000 feet above the sea, from Angoo to Kunkee, but to the east of Kunkee it becomes less prominent, being there separated into a series of detached hills and minor undulations, presenting a fine and interesting contour. This range throws off an important branch to the north, which composes the hilly ground between Lorungah and Bhuwanneah, and separates the drainage of the Hoharoo Valley from Lorungah.

In the valley last named a small patch of the boulder conglomerate is exposed in the bed of the nullah on the north-east of Lorungah village; the area exposed is but small, nevertheless there is quite sufficient developed for the purpose of showing the analogy existing between the fundamental rocks of this field, and the one in the Bocahroh valley, where the same sequence actually occurs. The coal-measures near the Lorungah village make

a remarkable bend towards the east, occupying the whole area of low land interposed between the hilly ranges previously alluded to. On a reference to the accompanying map it will at once be seen that this narrow trough of coal-bearing strata, occupies on the whole a lower level than the conglomerates composing the range to the westward of Lorungah, which occupy the same geological parallel in the general section of the series ; this difference in the altitude, and the marked difference in the general direction of the measures here developed, have been ascertained to be the result of a series of movements produced by the great fault bearing north and south, and the other faults (delineated on the map,) forming the boundary of the coal-field. This eastern trough-like depression of coal strata contains only the lowest coal-bearing measures, and part of the black and grey argillaceous shale containing the clay ironstones or the carbonate of iron ; the upper beds developed in other parts of this field to the westward, have here been removed by denudation. Beneath the above-mentioned black and grey argillaceous shales, (which by the bye are identical with the shales of the same lithological composition developed in the Damoodah and Adji great coal-field,) we have the usual alternations of sandstones, conglomerates, and thin beds of shale and beds of coal, some of

which are of a superior quality. On the meridian of Rackbah the eastern end of the coal-field has been ascertained to be two and a half miles broad; the black and grey argillaceous shales and iron-stones form a trough-like cavity dipping towards a common centre; the northern declivity at an angle of 40° and the southern at 30°; but on the north of the boundary of the shales, the angle in dip is considerably less, varying from 10° to 30°. In the bed of the stream which runs on the west of Kuppeah, there is a small anticlinal line, the northern declivity being 8°, and the southern 10°. It is expedient further to observe that the southern junction of this end of the field is cut off only a few hundred feet from the base of the shales alluded to above, but on the north basset we have nearly the whole of the lower coal-bearing measures developed, hence, the evidence relative to the result produced by this line of fracture is as complete as could be desired.

In the nullah previously mentioned four beds of coal have been found, three of which are to the south of Kuppeah and one to the north; these beds dip south (with the exception of the north roll produced by the anticlinal line before-mentioned,) and vary in thickness from 3 to 10 feet, one of which is composed of hard bright coal, fully answering all the purposes required; the other beds

appear somewhat inferior in quality, but still I am perfectly satisfied that abundance of good coal exists in this locality; yet it is with extreme regret I have to announce that the physical arrangement of the surrounding country is such as to prevent the coal here developed from being made available for either the inland or sea-going steamers.

To the west of Lorungah this trough of measures above referred to joins the main field by a narrow neck only one mile broad; this junction is formed by the interposition of the great north fault, on the west side of which the coal-field swells out to 8 miles from north to south, and occupies, as will be seen by inspecting the accompanying map, an area of about 70 square miles.

At the base of the Ghatee, through which the new road from Hazareebagh to Chota Nagpore passes, and distant from the former station 11 miles, the coal-measures are first seen in that direction, in juxtaposition with crystalline white quartz, pseudomorphous quartz, and compact felspar associated with talcose rocks, passing into schists. The coal-measures at this point, as well as along the northern basset of this field, bear strong evidence of having been subject to lateral pressure: the sandstones, conglomerates, beds of coal and associated shales developed along this line invariably dip south, at angles varying from 30° to 35°. The first seam

of coal is seen on the surface at a distance of 120 feet from the great north fault, and appears to be of an inferior quality. The next seam of coal is exposed on the surface 250 feet further south than the seam just alluded to, associated with black carbonaceous shale, which is so much mixed up with the coal itself (from lateral squeezing) that the thickness of the coal both above and below it cannot be measured; this, coupled with the high angle of dip, and the inferior quality of the coal itself, would justify the conclusion, that they are of no commercial value. The following is a section of the measures here alluded to, which form part of the lower division of the coal series:—

Descending.

		Ft.	In.
1.	Grey and brown conglomerate, brown sandstone and thin bands of grey shale	96	0
2.	Sandstone	42	0
3.	Grey argill. shale	8	0
4.	Conglomerate	12	0
5.	Grey argill. shale	22	0
6.	Brown sandstone	60	0
7.	Grey and brown shale, with nodules of clay ironstone	22	0
8.	Grey and brown sandstone	20	0
9.	Shale and sandstone	45	0
10.	Conglomerate and sandstone	117	0
11.	Black carbon. shale		
12.	*Coal* contorted		
13.	Black carbon. shale	40	0
14.	*Coal* contorted		
15.	Black Shale		

16.	Puddingstone	30	0
17.	Black shale and *coal* mixed	18	0
18.	Sandstones	3	0
19.	Black shale and bands of *coal*	4	0
20.	Grey sandstone	72	0
21.	Greenish yellow marl and sandstone, mixed with pebbles of white quartz	70	0
	Great north fault crystalline rocks		

The following figure will illustrate the relative position of the beds detailed in the last section and the crystalline rocks referred to.

Proceeding in a westerly direction from the above site, the coal-measures continue to abut against the base of the range of hills flanking this coal-field on the north, but to the west of the village of Mhotrah, and only 600 feet from the road to Badam, the grey sandstones of the coal-measures are exposed on the surface, dipping south at an angle of only 14°, while those on the extreme margin of the field continue to dip at angles varying from 20° to 35°.

Between the villages of Chundeal and Lackhora, a light grey argillaceous shale, containing arenaceous bands, is exposed in the bed of the nullah running between these villages: this shale also dips at a sharp angle bearing near the great north fault. In this direction there are no seams of coal exposed on the surface, it being invariably covered over somewhat extensively with alluvium, containing the calcareous nodules so commonly observed in Bengal and the N. W. Provinces.

This is to be very much regretted, especially as the measures towards the centre of this field are occasionally seen to be very nearly horizontal, and there is every reason to suppose that a great many seams of superior coal occur in this part of the series, and judging from analogy, I am justified in concluding that these measures extend under a very large area towards the west, and afford every facility of being worked on an extensive scale by the aid of ordinary machinery.

However, to the north-east of Badam, in the bed of Thumadee Nuddee, the evidence is more satisfactory and conclusive; here the sandstones, shales and thick beds of conglomerate, together with beds of coal, are extensively exposed, and constitute the range of hills branching off from the great chain to the south, and separating the drainage of this valley from that of Lorungah. Following the course

of the above-named stream several seams of coal are exposed on the surface. The measures detailed in the following section embrace the whole of the beds above alluded to, which will afford some insight into their composition and economic value, and lastly, their geological equivalents in the Damoodah Valley will be readily recognised.

Section of the Measures seen in the bed of the Thumadee Nullah and along its margin—

Descending Order.

		Ft.	*In.*
1.	Grey conglomerate	83	0
2.	Thin bedded sandstone coarse grained ...	2	6
3.	Ferruginous marl	2	0
4.	Grey aren. shale micaceous and hard ...	1	7
5.	Ditto softer with black carbonaceous stains	3	0
6.	Grey shale	9	0
7.	Brown sandstone and shale	63	0
8.	Shale...	0	9
9.	Bands of sandstone	0	3
10.	Argillaceous shale	1	9
11.	Bands of sandstone	0	3
12.	Argillaceous shale with stains of coal ...	1	2
13.	Sandstone	0	5
14.	Carbonaceous shale...	0	5
15.	Sandstone	0	3
16.	Black carbonaceous shale	0	9
17.	Brown sandstone	0	2
18.	Sandstones with bands of argill. ironstone and coal stains	1	2
19.	Brown sandstone irregular...	2	6
20.	Shale...	0	9

		Ft.	In.
21.	Grey sandstone and shale	2	6
22.	Black argill. shale and nodules of clay iron-stones	2	6
23.	Black shale micaceous	2	0
24.	Band of carbonate of iron	0	2
25.	Black argill shale	4	0
26.	Grey sandstone	0	3
27.	Band of carbonate of iron	0	4
28.	Black argill. shale	2	0
29.	Band of carbonate of iron	0	2
30.	Black argill. shale	2	4
31.	Carbonate of iron containing crystals of pyrites of Iron...	0	2
32.	Black argillaceous shale containing large nodules of carbonate of Iron	8	0
33.	Grey sandstone thick bedded and stained with the oxide of Iron	10	0
34.	Yellowish brown sandstone irregularly bedded; at the bottom beds coloured puce	7	6
35.	Yellow sandstone with plates of talc ...	0	7
36.	Black and grey shale in thin bands ...	0	9
37.	Arenaceous shale with black stains ...	1	9
38.	Grey argillo-arenaceous shale	2	0
39.	Grey sandstone coarse grained	3	0
40.	Shale...	0	2
41.	*Coal*	0	1
42.	Black carbonaceous shale	0	3
43.	Grey and black argillaceous shale ...	2	6
44.	Sandstone brown and grey...	2	0
45.	Black shale	1	6
46.	Grey sandstone fine grained	7	0
47.	Arenaceous shale	0	6
48.	Grey sandstone	1	6
49.	Shale...	0	1
50.	Sandstone irregular	1	0
51.	Sandstone and shale alternating	2	4
52.	*Coal*	0	2

		Ft.	*In.*
53.	Grey shale micaceous	0	6
54.	Aren. shale	4	0
55.	Grey and brown sandstone	4	6
56.	Grey shale	2	6
57.	*Coal*	12	0
58.	Shale	1	6
59.	*Coal*, superior	2	0
60.	Grey shale	3	0
61.	Black aren. shale	4	0
62.	Carbonate of iron	0	3
63.	Black and grey argill. shale	14	0
64.	Arenaceous shale stained red	2	0
65.	Grey sandstone, containing pebbles of white quartz	3	0
66.	Grey conglomerate, containing large boulders of black and white quartz ...	30	0
67.	Black and grey aren. shale	2	0
68.	Fine grained sandstone, stained red and grey	4	6
69.	Black argill. shale	2	2
70.	Brown sandstone	0	8
71.	Grey aren. shale	1	10
72.	Carbonaceous shale and coal	0	6
73.	Grey aren. shale	0	1
74.	*Coal*	1	3
75.	Black shale	0	9
76.	*Coal*	0	3
77.	Black shale	0	10
78.	*Coal*	1	2
79.	A band of red ironstone	0	10
80.	Grey argillo-aren. shale	5	0
81.	Ditto, with aren. bands *more* indurated ...	3	0
82.	Grey argill-aren. shale	8	0
83.	Black, grey, and red sandstone	4	0
84.	Grey conglomerate	6	0
85.	Black carbon. shale and coal	4	0
86.	Shale and sandstone	36	0

		Ft.	In.
87.	Black carbon. shale, and	110	0
88.	Sandstone and conglomerate ...		
89.	Grey and brown sandstone coarse grained	10	0
90.	Light grey shale	9	0
91.	Sandstone and shale alternating in thin bands, color puce and brown ...	4	0
92.	Black and grey argillo-aren. shale ...	8	0
93.	Grey and brown sandstone	4	0
94.	Grey aren. shale	1	0
95.	Superior *coal*	0	10
96.	Black shale	1	0
97.	Black rock	0	4
98.	*Coal* (Colonel Ouseley's coal)	12	0
99.	Grey aren. underbed	8	0
100.	Grey shale	7	0
101.	Grey sandstone coarse grained	10	0
102.	*Coal*, thickness not seen	0	0

The measures detailed above have an aggregate thickness of 572 feet, composed of sandstones, conglomerates, beds of shale, containing the clay ironstones or carbonate of iron, together with 10 beds or seams of coal having a total thickness of 28 feet and 10 inches. These beds there can be no difficulty in at once identifying as part of the upper members of the lower coal-bearing strata; they bear a close analogy to the coal strata developed at Taldangah and along the Adji river, to which I believe they correspond in the great section of the coal strata.

The rocks referred to in the last section constitute, as before mentioned, part of the range of hills which separates the drainage of the Lorungah valley

from the Hoharoo, and dip to the south of west at angles varying from 12° to 14°. But along the great south fault the measures dip towards the north, from 10° to 15°; these rocks, notwithstanding, become less inclined towards the centre of the fields, where the coal-measures are all but horizontal. The great escarpment on the west and south of the Hoharoo nullah, which is about 700 feet above the surrounding valley, and entirely constituted of the superior sandstones of the coal-measures, is a beautiful example illustrative of the fact just alluded to; this hill, however, is not to be compared with the gigantic Looghoo, which is more than double its height, and composed of sandstone and subordinate beds of shale of the same parts of the coal series; but it is quite sufficient for the purpose of showing the analogy existing between these coal-fields, and further demonstrating that the black and grey argillaceous shales, containing the carbonate of iron, occupy an intermediate position between the sandstones composing the hills referred to above, and the subjacent coal-bearing conglomerates. It is also worthy of remark, that the seam of coal crossing the Sancheraie nullah, and shown to Mr. Assistant Surgeon Dunbar in 1841, belongs to this part of the coal series, and is seen to dip at an angle of 8° toward the escarpment, but before it reaches the Hoharoo nul-

lah the shale and sandstones superior in position are perfectly horizontal. The coal itself is nearly 6 feet thick and of an inferior quality, covered by a bed of grey argillo-arenaceous shale: the direction of the out-crop, or the line of strike of this coal is nearly north and south, but after passing through the village of Nowhatta, it curves in a westerly direction. Between two and three miles to the south of this site, another out-crop of coal is seen to cross the Hoharoo, near to a small village called Khondroo, and dip at an angle of 12° towards the north-west: this coal being associated with the sandstones and conglomerates inferior in position to the rocks developed in the bed of the Sancheraie, must be regarded as a distinct bed; these coal sites will be found on the accompanying map.

It is highly expedient here to remark that the coal-field under contemplation and the one developed in the Bocahroh valley, are as complete an emblem of the one geologically examined during 1847 in the Damoodah valley, as could be well conceived, hence, the opinions and statements promulgated relative to the general superficial character of the carboniferous strata, and consequent inferior quality of the fuel contained in the Damoodah and Adji great coal-field, are no longer admissible, inasmuch as it is now a known fact that the lithological composition of the coal-mea-

sures developed on the south-west frontier, and of the one posited in the locality above noted is the same in both localities respectively: the great leading groups of strata are also perfectly indentical. The analogy existing between the coal-fields here alluded to, must negative the premature generalisation arrived at by the Coal Committee relative to the distribution of superior coal, which was asserted in this section of our Indian empire to be associated with the strata now composing the central table land, and consequently corresponded with the Nerbudda, Sylhet, Cherra Ponji and Assam coals in point of quality; however, as the hypothesis alluded to has been fully treated of in my report on the Damoodah Valley, it is only necessary here to state the fact, namely, the coal-fields posited in the zillah of Ramghur do not compose a single biggah of the so-called "central table land of Hazareebagh": the coal-fields here referred to occupy in a great measure the low undulating land to the south of the main chain of hills flanking the table land mentioned by the Committee, therefore, they had no substantial grounds for asserting that the coal districts of the south-west frontier, Central India, Cherra Poonji and Assam, should contain superior coal to that existing in the Damoodah and Adji great coal-field, where the coal-bearing strata have been shown to be developed on a very large scale.

And I may further add that that great field extends over a larger area than was generally supposed, and I am fully warranted in stating, from analogous facts, that the best description of coal will be obtained from that invaluable mineral field. I state this not for the purpose of advancing or supporting any theoretical views of my own upon the subject of the relative economic value and distribution of coal in India, but solely with a view of drawing public attention to the only coal-field in my opinion which will be able to compete with English coal in the metropolis of British India, both as regards quality and price. Further, the Damoodah coal-field, from its geographical position, is the only one from which the capital can be supplied with an article so essentially required for various purposes at a moderately cheap rate.

THE MANUFACTURE OF IRON.

THE manufacture of iron on the south-west frontier, is by no means organized on any specific plan, by which iron could be obtained in large quantities, or of a quality suitable for railroad purposes. How long the manufacture of iron has been carried on by the natives is difficult to decide, in the absence of records bearing upon the subject. The workers of iron in this country are separated into two castes; namely, the Agoriah and Lohareah; the former are considered the lowest caste of the two, and are the persons who collect the ores and work them through the first process; the iron produced by them in a crude state is sold to the Lohareah, who work it through another process, which will be described. Iron is made at Bulleah, Nowhatta, Lackhora, Chundulparah, Angoo, and at several places along the margins of the jungles; the furnaces now in operation will rather exceed 60 in number of both descriptions, which are exceedingly primitive and simple in their construction, being built of alluvial clay, about 4 feet high on an average: the area of the interior at the hearth will measure from 90 to 100 square inches,

and the section upwards (near the top) gradually diminishes to half that area. There is but one opening at the bottom, and is that through which the blast pipe enters; this opening when the furnace is at work is stopped up with clay and sand.

The blast bellows are also very primitive, so much so, that any one would suppose they were some of the relics preserved from Noah's Ark, and handed down from father to son without any alteration whatever; they are made of wood, and are of a circular form, measuring from 12 to 15 inches diameter, and about 6 to 9 inches deep: the upper surface is composed of leather, in the centre of which the valve hole is cut; the nozzle is made of a bamboo pipe, about 2 feet long. Two of these bellows are indispensably necessary for each furnace; they are placed close together, and the nozzles of both introduced into the orifice of a clay pipe, which is placed near the bottom of the furnace, with one end introduced into the hearth. The working gear is also as simple as the construction of the bellows itself, being composed of only a piece of bamboo, from 5 to 6 feet long, one end of which is stuck in the background, and the other bent down and tied to the upper surface of the bellows.

Having described, as briefly as possible, the whole of the apparatus belonging to the iron fur-

naces in India, it will not, it is to be presumed, be uninteresting to describe, in the next place, the working process, which is as follows:—The furnace, in the first instance (after adjusting the bellows and its appendages) is filled with charcoal, which is set on fire through the blast clay pipe by introducing a small piece of ignited charcoal. A little water is also thrown over the leather surface of the bellows so as to keep it moist. In the next place a man ascends with a foot on each, adjusting himself in a such a manner so as to bring each heel over the hole cut in the upper surface of the bellows, as before described; the first motion is downward pressure, with the heel firmly pressed on the valve hole; this task having been accomplished, the other foot performs the same office; and by the removal of the greater part of the man's weight, which was in the first instance on the bellows first set in motion, the bent bamboo lifts the leathern surface to its original position. This alternate motion of the feet is continued by one man for nearly half an hour, when he is replaced by another. When a stronger blast is required than can be obtained by the labour of one man, a woman also gets on the bellows, holding on with her arms clasped round the man's waist. As soon as the first charge of charcoal appears red hot on the top of the furnace, a small basket-full of fresh charcoal is thrown

over it, and subsequently the iron ore, which had been previously pounded down into small grains, is sprinkled over the fresh fuel thrown on. Each charge of ore would weigh about one seer. After this process has been continued for about an hour, a small hole is made in the central opening of the furnace in a slanting direction upwards, sometimes on the left and right side of the blast clay pipe; this is called the slag hole, through which the slag runs out. The whole smelting process is completed in about three hours; when the blast apparatus is removed, and the sand and clay which dammed up the entrance into the hearth are also taken away, water is thrown over the unburnt charcoal left in the furnace. As soon as this is removed, which is generally accomplished in two or three minutes, the crude iron is next brought out in a *hard lump*, mixed up with unburnt charcoal; in this state it is sold to the Lohareah at the rate of three kutchah maunds of 30 seers each per rupee. The Agoreah only work at iron-making during the cold and hot weather; they are employed during the rains in agricultural pursuits. The tax levied by the Zemindar on each furnace is 2 annas.

The refining furnaces, which are worked by the Lohareah, are built of precisely the same material, and of the same size and construction, as those pre-

viously described, the only difference that exists is in the form of the blast bellows, which is a rude imitation of our blacksmith's bellows at home.

The refining or second process is exceedingly simple, and worthy of being recorded, and which will indubitably show that the manufacture of iron by the natives is in a very crude state, and is likely to remain so, unless they are taught the improved methods now adopted in the civilized world. The iron produced by the first process having been sold to the Lohareah, it is by them broken up into small pieces ; this being accomplished, the furnace is prepared as in the last process, and ignited in the same manner. When it has acquired the proper degree of heat, which is indicated as soon as the charcoal on the top of the furnace becomes red hot, fresh fuel is thrown on the furnace, covering the whole orifice, and piled up in the form of a cone; the pieces of iron previously prepared are in the next place thrown on the charcoal ; this process is continued for about 2 hours, during which time 30 seers of the crude iron have been used ; the scoria being drawn off through small holes made by penetrating a stick through the clay and sand damming up the entrance as in the last process: this slag or scoria is of a jet black colour, and highly magnetic ; this fact, together with the great loss in weight in converting the pig iron into a malleable

state, would induce me to conclude that nearly 40 per cent. of the iron is absolutely lost in consequence of the rude mode of manufacture, which at present yields only 10 seers of bar iron from 30 seers of pig or "gheeree." The ball of iron produced by this process is taken out from the hearth in a semi-fluid state, and hammered into a bar; this constitutes the bazaar iron of India. The duty of one furnace per diem is 90 seers of malleable iron, and the cost of charcoal consumed during the process is said to be 5 annas. It takes six men to work each furnace; the man whose duty it is to hold the ball of iron to be hammered gets 4 annas per diem, and the others get 2 annas each. This iron sells at the rate of 35 seers per rupee. At Bulleah and Nowhatta, there are 26 refining furnaces in operation from January until the end of the hot weather. Most of the iron manufactured on this frontier is sold to native merchants residing at Patna and Dinapore, on the Ganges, who make advances at the commencement of the seasons through their agents, who are deputed to the spot, for the purpose of obtaining proper security for the due performance of the contracts entered into.

The iron refineries in this section of India were formerly exclusively erected at Ramghur, the capital of the district; but one of the former Rajahs was advised by his Bhramins to leave

the place, as it was considered unlucky to reside there, and moreover, the Ranee failing to have children, he was induced to leave the ancient seat of Government for Echack, where, as the tradition goes, the lady was more lucky; this circumstance, it is said, induced them to reside there ever since, and was also the reason which induced the greater part of the villagers to shift their quarters to Bulleah, Nowhatta and the adjoining villages, where the iron refineries have ever since been carried on. Ramghur is situate in the heart of a jungly district, on the south side of the Damoodah river, it is nevertheless a fine-looking place, with a park-like aspect, studded with large trees and Mangoe topes for several square miles, and flanked on the south side by a range of high hills, between two and three thousand feet above the sea; these peak-like eminences, covered with vegetation, and the roaring of the waters of the Damoodah over the rapids near this place, add a degree of wild romance to the surrounding landscape, which, coupled with the superstition of the people, makes Ramghur rather a terrible place to reside at.

There is one important fact connected with the manufacture of iron in this country by the present mode, which I believe is not generally known, otherwise the opinions that have of late been published on the subject of obtaining native-made

iron for the construction of railroads in India, would not have been hazarded. However desirable it might be to procure the iron for Indian Railroads from native labour, it is indispensably necessary to mention, that with the present mode of manufacture, which has been shown to be so crude and imperfect, iron in the first place could not be made in sufficient quantity to meet the demand required, and certainly it could not be made of a quality suitable for railroad purposes. The great objection to native iron being used for such an important purpose as the construction of a railroad is this, *viz.* it has not been sufficiently smelted during the first and second processes, in neither of which has the iron (as now made) been in a perfectly liquid state—that is to say, the ball of crude iron produced from the first process was not all in a molten state at one and the same time in the bottom of the furnace. To explain this it is only necessary to remark that the first small quantity of liquid iron after passing below the nozzle of the blast pipe to the bottom of the hearth, (which, be it observed, is comparatively a cold bottom,) becomes solid, and forms a nucleus for the metal which subsequently descends, and becomes, as it were, agglomerated with it and unburnt charcoal. The same remarks will apply with equal force to the second process, during which the natives up

here have never yet been able to run their iron from the furnace in a liquid state, which they are exceedingly anxious to accomplish, with a view of attempting to cast cooking-pots, for which a large sale would be found amongst the native community. The facts above-mentioned will be sufficient to convince any one acquainted with the manufacture of iron, that the balls of iron produced from the second process have not been kept sufficiently heated to draw off all the scoria contained in them, and much less to produce proper cementation of the whole mass constituting a single ball or charge, which is composed of at least several hundred different parts, and united into one mass at different times, and at unequal temperatures.

The natives of this country are ingenious, and capable of doing a great deal with small means, but it is perfectly visionary and ridiculous to expect to procure malleable iron adapted for rail-roads by the native mode of manufacture, especially from such furnaces, and by such a process as that previously described.

If India is to have rail-roads, (of which there is every probability, as soon as the present political agitation of Europe has somewhat subsided, and public confidence restored; but so long as the present state of things continue, it is not very probable that any great rail-road scheme will be

carried into operation, either in this country or in Europe,) when the proper time arrives to commence this great and national undertaking in India, the importance of procuring a constant and cheap supply of iron of first-rate quality for its construction, must command the attention of those whose duty it will be to carry out a work of such magnitude. However, it has been fully demonstrated that India possesses all the essential elements for making iron on the English system, which will be found to answer all the purposes required; this being an important fact, government will deem it a point of too much national consequence not to support a branch of industry, which would have every tendency to ameliorate the condition of the poorer inhabitants of the country. It is also very certain that the railroad proprietors, on finding that a great saving would accrue to themselves by its adoption, would deem it of paramount importance to establish iron works in connexion with the main lines under contemplation, provided it could be clearly established to be a tangible undertaking, without absorbing too much capital in their erection, and that the consumption of malleable iron in India would be sufficient to keep an establishment of the kind in constant operation, which in point of fact is of primary consideration, and upon which the propriety of

erecting iron-works in this country (on the English mode) would mainly depend.

It is indispensably necessary to remark that without the prospect of a rail-road through the coal and metalliferous districts, iron works of any magnitude would never answer, especially as the present consumption of malleable iron is very small, and that of cast iron would never pay capitalists for the risk incurred; but in the event of a railroad being decided on, an establishment of 30 furnaces, capable of making 40 tons each per week, would be quite sufficient to supply the railroads contemplated on this side of India, that is assuming 100 miles of the main line would be completed annually after the first two years, which would be absorbed in getting the establishment into working order, and the direction of the line permanently settled.

As it has been fully demonstrated in my report on the Damoodah Coal-field that coal and iron abound in that locality, and that the cost of the raw materials requisite for the manufacture of malleable iron will be considerably less in this country than in England, it is therefore only necessary now to add, that, under judicious management, there cannot be a shadow of doubt, iron could be made in India quite as good as Welsh or English iron, if the same system be adopted.

However, before concluding this brief sketch on the iron trade, it is of the greatest importance to mention, there would be many difficulties to encounter in this country. Few persons, unacquainted with the habits of the people and their religious prejudices, would believe there could exist in any section of the globe a class of people so blind to their own interest as the Hindoo family, who prefer adhering to the customs of their forefathers rather than adopt modern improvements; this would be especially felt on the introduction of a new branch of industry such as the iron trade, and it may be stated with great truth, that no remuneration, in my opinion, would induce the lower classes of Hindoos to work during their poojahs, which occur several times during the year, and continue for even 14 days together. This would be a serious drawback to the erection of iron works in this country, consequently, a great and serious loss would arise, from the absolute necessity of blowing out the iron furnaces when the holidays alluded to took place. It therefore becomes a question for the consideration of those who might feel disposed to embark capital in an undertaking of the sort to inquire previously, whether any class of people (natives of India) could be organized and induced to work all the year round, and to disregard what is looked upon

by every native, from the lowest to the highest caste, as the high road to Heaven. The love of caste no doubt was highly beneficial when first established, but at the present time it has every tendency to retard all improvements in the country, and keep the people in a state of abject poverty and gross ignorance.

GENERAL REMARKS.

The geological structure of the rocks composing the south-west frontier, being on the whole perfectly identical and coeval with the rocks developed in zillahs Beerbhoom, West Burdwan or Bankoorah, may, if we except the coal-fields, be said, in a geological point of view, to be anything but interesting. After leaving the coal strata, the crystalline formation composes the surrounding country for several thousand square miles, the mineral aspect of which is persistent on a scale equally large; this clearly indicates that the conditions essential for the production of rocks of this family have extended over considerable areas, and have produced analogous results in localities far distant from each other, which could only happen from a general uniformity of the then existing causes. The southern division of the peninsula of India, being of vast extent, and the greater part of it inaccesible to Europeans, during 7 months in the year, will, it is to be apprehended, prevent the geographical extent of the

inferior stratified rocks from being defined for many years. The climate and inaccessible nature of the country is a serious draw-back to prosecuting geological researches in the interior, with anything like minuteness.

The absence of the fossiliferous strata is a peculiar characteristic feature in this part of India : it may therefore be interesting to offer a few general remarks, relative to the absence of organic remains, and the probable causes which have so generally overthrown the whole of the strata with which they are associated, from the earliest period of the organization of animal life up to a recent date. From what is known of the primary, secondary, and tertiary fossiliferous strata in other sections of the world, they are collectively of great bulk, and extend over vast and extensive tracts of country both in Europe and America; but in Bengal there is not a vestige of the cambrian, silurian, old red sandstone, carboniferous limestone, or indeed, any rocks superior to the coal-measures to be found. Whatever might have been the real cause of those great and overwhelming catastrophies, is, in the present state of our knowledge of the geological structure of the vast peninsula of India, difficult of solution; it may be stated notwithstanding, that the laws then in active operation overthrew the entire organization of animal life and the sedimentary depo-

sit, essentially necessary for the existence and development of the kind of animal life now known to exist in a fossil state, extending too through suites of rocks embracing a geological thickness of at least 50,000 feet; hence, it can be hardly supposed that such enormous masses of calcareous and sedimentary accumulations as usually constitute the whole body of fossiliferous strata had been deposited and subsequently removed by denudation. Had such been the case it would be but reasonable to expect to find a few patches in situ or some remnants in the form of drift, neither of which are to be found in this section of the Empire; and from all that can be gleaned regarding the geology of central and southern India, it appears that the middle and lower members of the Palæozoic strata are likewise wanting; but with respect to the superior rocks constituting the Mesozoic and Cainozoic strata, there cannot be a question of doubt of their existence in southern India, and also in the lower ranges of the Himalaya mountains; this important fact, together with the absence of those rocks in the district under consideration, would justify the conclusion that the lower ranges of the Himalaya mountains and southern India were simultaneously under the ocean, when this part of the great Vindyah chain was dry land, both prior and subsequent to the deposition of the coal-measures; this

view would be the simplest and probably the most reasonable mode of accounting for not only the absence of organic remains, but of the enormous bulk of sedimentary deposits too.

In the absence of the intrusion of igneous matter on any scale calculated to affect large masses of rocks, and the total absence of volcanic matter in the district under consideration, it would, therefore, be quite inconsistent to suppose that the mass of mineral matter now constituting the crystalline rocks had been fossiliferous rocks altered by heat, but they must be regarded as the fundamental of all sedimentary rocks, and forming no inconsiderable thickness of the crust of the globe.

The round hill on the north-east of the station of Hazareebagh, is composed of gneiss, hornblende, schist, and white quartz, and attains an altitude of 497 feet above the table land near the barracks. The Silwar or Telegraph hill to the east of the one above-mentioned is also composed of the same description of rocks, and is 513 feet above the same place. The Hoozool, another conspicuous hill lying to the south of the Silwars, attains an altitude of 1251 feet above the same point ; this hill is constituted of white quartz, massive felspar, and compact quartzose and hornblendic rocks occasionally containing plates of talc. Bhomnee hill is principally composed of nearly vertical beds of gneiss, contain-

ing quartz, felspar and hornblende, forming an exceedingly hard and compact fine-grained rock, admirably adapted for building purposes. The telegraph 5 miles to the north-west of the above-named station, is wholly composed of syenitic greenstone, and is about 200 feet above the table land; this is the only instance observed of the protrusion of a well-defined mass of Trappean matters in this vicinity. All the hills, (surrounding this station) with the exception of the Trappean hill just mentioned, contain brown magnetic iron ore, more or less, which is invariably associated with a rock principally composed of green crystals not larger than small grains of sand insoluble in heated nitric acid. About one mile to the north-east of the station, a large lode (20 yards broad) of this iron occurs under the most favorable circumstances for being worked on a large scale; it is associated with white quartz, and flanked on the south side by beds of gneiss dipping north at an angle of at least 70°. It will be interesting to mention that the lode here alluded to contains iron of two descriptions; one sort is externally of a jet black colour, but when fractured presents a homogeneous structure and resinous lustre, colour iron brown,*

* This is the Calderite of Mr. Piddington, described in the Journal Asiatic Society Bengal, Vol. XIX. p. 145, subsequently to Mr. Williams' decease.

does not act on the magnet, and is infusible in the native furnaces with charcoal; this probably arises in consequence of the iron being mixed up with too much silica. The other description is, however, much superior, of a brown colour, structure metallic, granular and mottled, and acts powerfully on the magnets; this iron although not so abundant on the surface of the lode as the other variety, is still developed in sufficient quantity for all useful purposes; the lode itself extends quite across the country, bearing 95° east of north and 5° north of west.

Iron ore of a similar description to that just described has also been observed to the north of the village of Murier, lying to the north-west of Hazareebagh, associated with white quartz, felspar and black talc, occasionally assuming the character of gneiss; this ore does not appear to form part of a lode, but is disseminated through the rock above-mentioned somewhat promiscuously. The natives of this part of the country have from time immemorial worked the iron ores from the crystalline rocks into a metallic state; extensive heaps of iron scoria are seen scattered over the country in sites where wood does not exist at present. Similar remains have also been observed in the interior of the country now covered by dense jungle. The wants of the native iron workers being few, they seldom settle down,

with a prospective view of opening iron mines on any specific plan; they appear satisfied by collecting what is exposed on the surface, and when that supply becomes exhausted, they invariably shift their quarters to new sites, where the iron ore can be obtained with little more trouble than the labour of picking it up. When the wants of the people of any country are few and limited, it is calculated to produce habits of idleness, which, in the long run, degenerate into every species of crime. The people inhabiting these jungles are notorious thieves.

The amount of pre-existing solid matter now constituting the inferior stratified rocks must be several miles in thickness, and probably attain a greater geological thickness than the whole of the fossiliferous strata from the Cambrian rocks to the tertiary series inclusive. In India these rocks occupy a larger area than any class of rocks of the same family developed in any part of Europe or elsewhere, hence the grand question to be solved is, how such a gigantic mass of strata became crystalline long prior to the deposition of the coal-measures. The high antiquity of the crystalline rocks cannot for a moment be doubted; they are evidently older than the coal-measures, and wherever they are seen together, (when not cut off by faults) these rocks are always lowest in the series, and form enormous sheets of stratified rocks, the

mechanical origin of which is very manifest; moreover, they are the fundamental rocks of the series of primary strata. With regard to the crystalline character pervading the whole series of inferior stratified rocks, it may be stated that a difference of opinion at present exists in the minds of European Geologists as to their probable origin. The view taken by several distinguished observers is, that these rocks were chemically and mechanically deposited in the same manner as most sedimentary strata, denuded from the unstratified crystalline crust of the planet, or, in other words, from pre-existing matter; others admit the mechanical origin of these rocks, but contend that their crystalline structure is mainly due to Plutonic agency, that is to say, altered by heat deeply seated in the earth under great pressure and on cooling it is supposed that a re-arrangement of the particles, or crystallization was produced. In support of this hypothesis the intrusion of igneous matter into fossiliferous strata, and their consequent partial metamorphosis into crystalline schist, is said to be an analogous phenomenon. However, be this as it may, the intrusion of igneous matter into stratified rocks when viewed in nature, has always been found to be limited in its operations, and fully inadequate to alter such a mass of rocks as usually constitute the stratified crystalline rocks, which are such bad

conductors of heat, and exceedingly difficult to reduce to a state of liquidity or even semi-fusion. The quartzose sandstone composing the hearths of our iron furnaces is a familiar example, and fully illustrative of the following fact, *viz.*, that certain siliceous rocks are capable of resisting almost the greatest artificial heat we are capable of producing, hence the heat essentially necessary to reduce the whole body of the crystalline stratified rocks, would have to be of such intensity as to melt down in the first instance a very large section of the primary crystalline crust of the planet into a fluid state before the inferior stratified rocks could be in the least affected; moreover, the lowest members of which would also have to be reduced into a liquid state before those constituting the upper series could in any degree be even heated; consequently, beds so circumstanced would lose all trace of their mechanical origin, which is manifestly not the fact, so far as the rocks under consideration are known to us.

The table land of Hazareebagh, and the adjacent country, composes part of the Vindhyah great chain, so well known to extend from the Gulph of Cambay in an easterly direction, to Rajmehal near the junction of the Bagherutty with the Ganges, where it finally disappears in that direction. The rocks constituting this section of the above-named

remarkable chain of hills, so celebrated for its picturesque wild scenery, belong to the inferior stratified crystalline rocks. Under this head are classed, gneiss (stratified granite) white compact crystalline quartz, pseudo-morphous and radiated quartz, protogene, talco-micaceous schists, pegmatite, hornblende rock passing into hornblende schist, schist rocks, and thick beds of salmon color felspar occasionally passing into schistose beds.

It will be interesting here to mention that gneiss is by no means the fundamental rock; but has been found in the locality to pervade the whole series of crystalline strata from top to bottom, it invariably forms beds from coarse to fine grained, sometimes assuming the character of a coarse grained granite, composed of quartz, felspar, and hornblende, the last-named mineral is occasionally seen in large crystals of various sizes down to small grains; when the small grains predominate the gneiss assumes a blacker appearance than is ordinarily seen in true granite; this is what should be strickly denominated the streaky variety, and generally speaking the commonest sort developed in the Vindhyah range. It is of common occurrence to see hornblende entirely disappear from gneiss, and replaced by black and white talc in large flakes. Mica on the whole is a scarce mineral, and is seldom seen to enter into the composition of

gneiss: it is in fact more commonly seen to enter into the composition of schistose beds occasionally observed to alternate with white quartz rock.

White crystalline quartz rocks generally form thick beds, dipping conformably with gneiss, and associated with every member of the crystalline formation, and may be said to be developed on a larger scale than the other members of the series, with the exception of gneiss. Pseudo-morphous and radiated quartz are mostly seen to be associated with compact felspar. The ghauts on the south of Hazareebagh are mostly composed of felspar, pseudo-morphous and radiated quartz: both varieties may be seen, and are of common occurrence in one and the same mass, and even in small specimens, these varieties are beautifully blended together, with rectangular empty cavities, the internal side coated with minute six-sided prisms of spangly quartz, in other specimens, we see the process much further advanced, when the cavities alluded to above are entirely filled with crystalline white quartz, closely aggregated and of a larger size than those which form a single covering on the internal surface of the cavity or chamber.

Protogene, or talcose granite, is composed of quartz, felspar, talc, and has more the appearance of an agglomeration of those minerals from the action of water, than from Plutonic agency: the quartz and

felspar always form the base, and in large crystals, and the plates of talc are generally largely disseminated through the mass somewhat promiscuously, the laminæ crossing each other in several directions. This rock is more generally developed in the vicinity of white quartz and felspar than with gneiss.

Hornblende rock appears under a variety of modifications in this district and seldom in the character of those compact black, magnetic masses commonly associated with Trappean rocks ; here it is mostly in beds perfectly stratified, and forms a coarse-grained rock composed of grains of white quartz and crystals of hornblende ; this sort is invariably very hard and compact ; however, when the quartz is replaced by felspar, the external surface presents a black glistening appearance, the felspar having decomposed, a fresh fracture will soon show that this is only superficial : this variety often passes into hornblende schist, and it is difficult to draw a line of demarcation between them. On the south side of Mudunpore, one march west of Sherghotty, there is a fine exhibition of what may be termed a porphyritic hornblendic granite ; there the hornblende crystals are exceedingly large, cemented in a matrix of quartz and felspar, which also show large crystals and faces. Three miles from Sherghotty, this belt of granite is in contact with brown felspathic beds evidently of trappean origin.

Black schorl enters somewhat largely into the composition of the crystalline rocks. About 5 miles to the south of Hazareebagh some fine specimens are seen imbedded in a granitic looking base of white quartz, the schorl fibres are arranged in bunches, radiating from a narrow base spreading out and expanding in every direction ; these beautifully delicate looking fibres are sometimes agglutinated together in hundreds and measure nearly an inch long. Schorl also appears in small broken fibres and disseminated in such profusion as to give the rocks in which they occur a perfectly black glistening appearance, and it is not uncommon in the granitoidal varieties of schorl rock to see separate crystals of tourmaline, invariably in prisms of six sides ; these crystals when broken present the usual conchoidal fracture.

Graphite granite has been found on the north of Hazareebagh station ; it appears to be in a vertical vein composed of a base of salmon color felspar and dirty white quartz in irregular veins, passing through the felspar. Granite properly speaking has not been seen on the table land of this district.

The rocks previously noted are exposed from the plains of Behar to Hazareebagh without manifesting any particular order of superposition. Gneiss is seen sometimes to repose on white quartz, felspar, hornblende rocks, and the softer schistose

beds, the whole mass has a constant dip north, the angles varying from 16° to 80°. It is impossible to look at such an enormous mass of mineral matter as constitutes the crystalline or inferior stratified rocks of this and the surrounding localities without being at once struck with the general uniformity of dip, stratification, and composition, pervading the whole area under consideration.

Although it has been shown in the preceding pages that a large deposit of both coal and iron ore of various qualities occur in this locality, it is however to be apprehended that, in consequence of the inaccessible nature of the country and the difficulties to traverse it at present, from the want of proper roads, years must elapse before any real advantage can arise to the inhabitants located in the regions to the south, from any amount of mineral wealth that section of the country may contain. It is hardly possible to conceive that a district so extensive, and possessing so many natural advantages, together with a climate said to be admirably adapted for the habitation of Europeans, should remain comparatively speaking nothing more or less than a vast area covered with jungle, with the exception of a few patches of cultivated land, amounting in the aggregate to about 1 biggah in 1,000; a district too without even a main line of communication to the interior for the convenience of tra-

vellers, much less for the conveyance of commerce, in the absence of which it cannot be expected that any capitalists would attempt to turn the mineral wealth of this important section of our Indian Empire to advantageous account. Unless the present mode of transit from the interior of the country to the Ganges and the capital be improved, India must for ever look to England for the supply of her metalliferous wants, notwithstanding her own soil abounds with all the mineral productions essentially required for the aggrandisement of the Empire. England is one of the finest examples which will ever appear on the records of the history of the world, of the rapid progress she has made in every branch of industry calculated to improve the social and moral condition of man; this, there can be no question of doubt, has arisen from the fortuitous circumstance of the splendidly developed supplies of coal and iron, which, coupled with the energies of her people, the facilities of cheap transit by roads, canals, and rail-roads, traversing the country from one end to the other, will continue most materially to influence the further advancement of her people in all that concerns their domestic comforts. India too has extensive deposits of mineral wealth, and a large population in the most deplorable state of ignorance; but still they are capable of being taught many important branches of industry, and

it yet remains to be seen whether these prospective advantages are to be realized for a people truly deserving of them, which be it remarked is only to be accomplished by the introduction of British skill and capital amongst them. It has been justly observed by Dr. Buckland.—"We need no further evidence to show that the presence of coal is, in an essential degree, the foundation of increasing population, riches and power, and of improvement in almost every art which administers to the necessities of mankind, and however remote may have been the period at which these materials of future beneficial dispensations were laid up in store, we may fairly assume that besides the immediate purposes effected at, or before the time of their deposition in the strata of the earth, an ulterior prospective view to the future uses of man formed part of the great design with which they were, ages ago, deposited in a manner so admirably adapted to the benefit of the human races."—B.'s B. T. v. 1. p. 535.

By inspecting the accompanying map, it will be found that the coal-fields here alluded to are surrounded on the north and south by chains of mountains, which it would appear has led most people to suppose presented the most formidable obstructions to the construction of a rail-road, and as the general opinion at present entertained has

been promulgated without any knowledge whatever of either the physical arrangements of the country, and much less of its geological structure, it is therefore essentially important to state that from the information acquired during the progress of the geological survey through these regions relative to the physical structure of the line of country composed of carboniferous strata, it appears to me to be formed by nature as the natural line for the construction of a rail-road from the capital to the North-West Provinces. The importance of this fact might be further enhanced by stating that there are no difficulties in the way of constructing a rail-road, but what might be overcome by engineering skill and a moderate outlay of capital. Moreover, if a comparatively continuous chain of coal-fields extending from Khyrasole (110 miles from Calcutta) through the Damoodah, Bocahroh, and Hoharoo vallies, embracing a line of country in a westerly direction for nearly 200 miles, is not of itself sufficient to give it a preference to all others, which would have to traverse enormous tracts of jungly country without probably any coal, I should at once give up all hope of ever seeing the mineral productions of this section of our Indian Empire made available for the purposes for which they were certainly created. If it were possible to estimate the future benefits such a line

of communication would bestow on the people located in these and the adjoining regions to the south, no doubt every attention would be paid to the subject of the value and importance of such a belt of mineral wealth as the one above noted, which I may further add would have every tendency to convert these vallies (now covered by enormously dense forests through which few Europeans have ever passed) into scenes of both mineral and agricultural industry.

However, if we calmly consider the vast strides which have during the last half century been made in Europe and America to cultivate all branches of national industry, (and the zeal which has been employed to develop the mineral wealth of the various countries has been attended with great success); the most casual observer cannot fail to be struck with the absence, in the district under consideration, of all that enterprise and intelligence characteristic of the times. Indeed, it is hardly possible to conceive there could exist that degree of shortsightedness on the part of those who have embarked their money in mining operations to expect any solid or permanent good to be derived from the agency employed, and means applied. Coal, it is true, has been worked in the valley for more than 30 years : notwithstanding this we have

no hesitation in stating there is not an establishment in the whole district worthy of the name of a colliery. This assertion may appear startling to those who have never visited the locality, but it is no less true, and will exhibit the incompetence of parties who have neither the zeal nor inclination to establish anything like a colliery, equal to the wants of the country, and would have the presumption to monopolize to themselves such a large coal-field as the Damoodah. The partial success which has hitherto attended this overgrasping principle, has arisen in some measure, from erroneous statements which have been made regarding the possessions of parties already in the field, and which were asserted to be so extensive as to preclude the possibility of new comers to obtain a footing ; this is quite a mistake, for it can be stated with great truth that there are several hundred square miles of land containing abundance of coal, which are procurable and may be taken by any party wishing to establish collieries in the locality and without interfering with any of the land alluded to in the existing interests. It is nevertheless proper to state here that there are great difficulties to overcome before the new comer can possibly succeed or get a permanent footing in the locality, and so long as the present order of things be permitted to go on unchecked, it is to

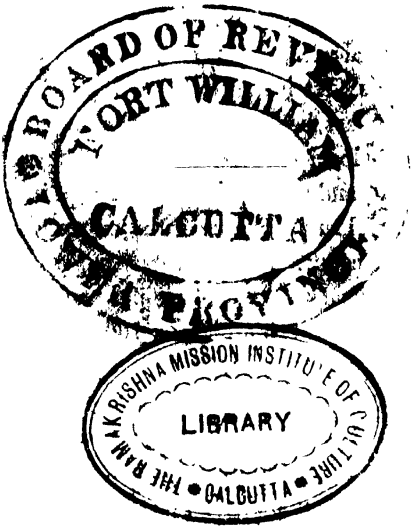
be apprehended there is little chance that any real good can arise from developing the mineral resources of the country.

It would appear that there is as much fault to be found with the system as with the individuals, which has already grown up to a dangerous precedent. We of course allude to the jobbing of coal land by the Natives, who are in the habit of letting the same lands to different parties. There appears great doubt whether the dependent talookdars, putneydars, darputneydars and pottahdars, have any legal right to grant deeds and pottahs separately for mining purposes, and reserving to themselves the profits arising from cultivation. It evidently would seem on the face of the perpetual settlement that their titles only extend to the superficial soil for the purposes of cultivation, but how far the landholders previously mentioned are justified in making sales and transfers of the minerals of the country as above adverted to is a question of the greatest importance for the consideration of Government to determine, before what really appear to be nothing more than assumptions of a very recent date become a general custom, for every dependent holder of land, from the talookdar down to the pottahdar, to claim the mineral wealth of the Empire, however valuable it might be. The continuance of such a system will in

the long run lead to nothing else but strife and internal commotion, and the elements of the disputes, which have already been a source of great annoyance to the Authorities, may be traced to it, in connexion with the following facts, *viz.*, in the localities there are no natural boundaries on the surface, which would enable the Authorities and the new comers to distinguish one property from another, and the consequence is that serious disputes arise in 9 cases out of 10 where land has been taken for mining or ghaut purposes, and the claims made by the plaintiffs, who are invariably the aggressors, are generally based on assumption with a view of involving the new comers in litigation so as to procrastinate all operations and finally disgust them with the locality,—indeed several cases have occurred where parties have been seriously maltreated. What has just been detailed is and has been a grievance much felt in the district, which together with the jobbing of coal lands may be termed the source or fountain head of all the great evils which have grown up with the Coal Trade, and ought to be corrected so as to place the locality on the high road of improvement and beyond any influence, which has a tendency to retard that amelioration of the Native population so essentially required. If there is no intention on the part of Government to assert their claims

to the minerals of the Empire, the most efficient plan that would appear to suggest itself so as to counteract and eradicate the evils so generally complained of would be to appoint an Officer, with full powers to make roads for the public convenience, especially in connexion with mining; further to call on all parties holding deeds or pottahs of mineral property, to define their boundaries by erecting permanent marks, built of stone pillars, and the boundaries so marked out in the presence of the contending parties or different claimants to be a final decision. In order to carry out the plans proposed with proper justice to all parties, it would, in the first instance, be advisable that the boundary pillars be built under the superintendence of the local officer and at the expense of Government, and subsequently to be kept in repair by the landholders. To meet the expenses to be incurred in connexion with these suggestions, I would recommend a tax of 4 pie per maund on all coal mined in Bengal, which on 100,000 tons, or 27 lacks of maunds, would realize 56,250 rupees, which sum, it is to be presumed, would be more than sufficient for the purpose. The above quantity, we have every reason to believe, will be mined in the Damoodah valley next year, and if the present mode of transport is to be improved or superseded by the introduction of a rail-road

through the locality, this quantity will progressively be augmented. There can be little doubt that a tax on coal will for many considerations be beneficial, and should Government deem it expedient to carry the above suggestions into operation, it would be advisable that the quantity of coal mined be determined at the collieries, allowing, of course, a fair deduction for wastage by transport from the mines to Calcutta.



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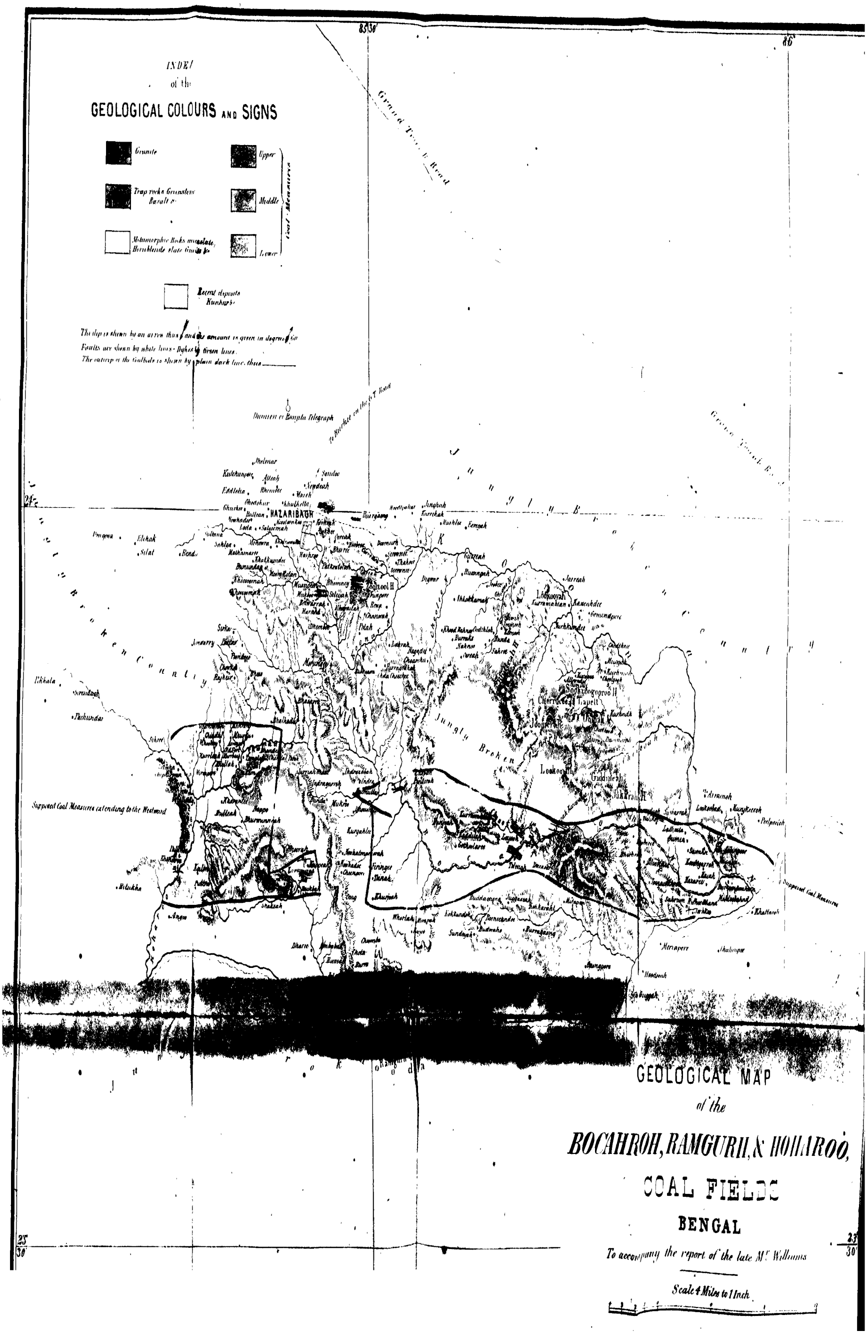
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